Sustainability Through Green Manufacturing System: An Applied Approach

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Lecture – 16
Green Manufacturing Modelling Continued: Indices for Green Manufacturing

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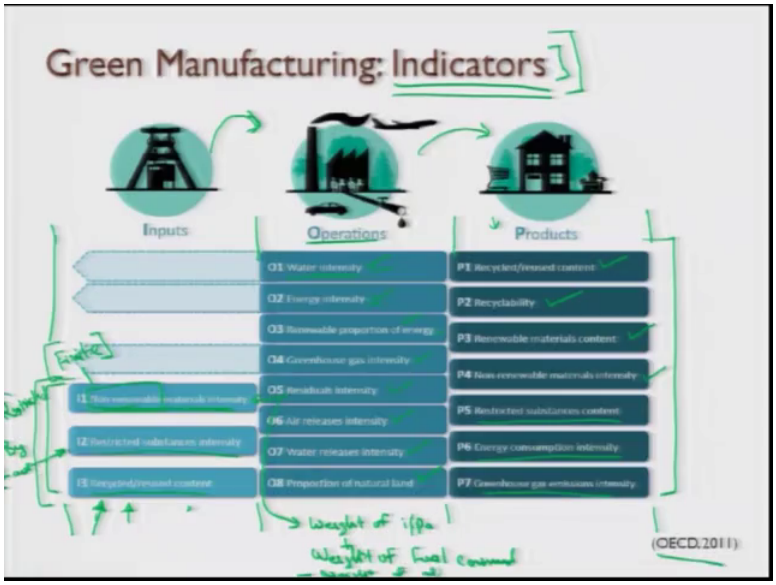

So, next I will come to indicators, green manufacturing indicators. So, what are indicators, indicators are something that indicates the state or level of something those metrics were actually the yardstick, actually those that was the parameter or the variables can be defined in the other way. So, these are my indicators, these can have other further matrix in it. So, this is a figure or the indicators, those are given by OECD. OECD is a organization for economic cooperation and development, which is an international organization, with a mission to promote policies, that will improve the economic and societal wellbeing. So, people all around the world. So, they came up with the indicators and they divided into three different stages here.

So, if you could recall, we had input operations and products as our three major stages in manufacturing. So, they had a total of 3 plus 8 plus 7 18 indicators of which 3 indicators are inputs. Inputs are non renewable materials and intensity and restricted substances into intensity recycle and reused content, these indicators tell us that how sustainable our

factory is how sustainable our manufacturing system is then in operations water intensity energy, intensity renewal proportion of energy, green house gas intensity residues that are produced air released, that is the air release intensity, that is within our factory or maybe to our environment then water release intensity.

Now, proportion of natural land that is being occupied by the factory in products. Finally, when the products, these inputs go does this go to manufacturing concerned after manufacturing, when the end user is there he says what is recycle and reused content here also then recyclability of my product renewable materials content, then non renewable materials intensity, here restricted substances content then energy consumption intensity of the product here at during a use, green house gases and machines intensity. So, these all indicators were given by OECD.

So, I will give a little detail of these indicators here. So, what is non renewable intensity here? Non renewable material intensity, non-renewable, we mean something that is finite that is that cannot be renewed. So, in general the non renewable resources are such as iron, ore, silver, copper. So, these are very relative to production, other materials are also there, other metals and minerals are there, that are considered critical due to their high risk of maintaining supply or maybe high impact on economy, if the supply was reduced. Some of the very critical minerals, here include rare earth elements rhodium, platinum, manganese, and non renewable materials. Here are critical, the extracting processing transporting of these consumes energy and these also generate residuals, these residuals is there. So, then this intensity this residual is already there.

So, this indicator in the year, we use of the substances, that are restricted by law. So, these are the substances, which are restricted for example, in certain, if this is lead blue color and (Refer Time: 04:11) color and those are all restricted to use and if one has to use that, he has to pay something back to recover the environmental loss in this case. So, next I have is recycle or reused content here. Now recycle or by recycle or reused content, here means this energy to produce the product, maybe renewable or maybe non renewable, but if it is recycled or reused, it will always have better environmental better eco efficiency I would say here. So, this indicator accounts for all the material inputs that are to be used for manufacturing process in your facility by weight other than fuel and water. It excludes materials that are recycled and reused within the facility. So, this

indicator is also very important. The increasing recycle and reused content of non and energy material will reduce that total amount of new materials required.

So, next I come to my operations indicators. Here, in this case the first one is water intensity. Now, water intensity, this indicator covers the water that is used in my manufacturing. There are certain manufacturing process, is which are water intensive and certain which are not for example, in metal manufacturing the water intensity is low in leather manufacturing and in certain chemical industry, the water intensity is high and in this case the water intensity becomes more critical factor.

So, now energy, we have discussed a lot about this one renewable proportion of energy this also we will cover by renewable proportion of energy. For example, the company might be using solar energy or wind energy as some part of the energy that is, that total energy that is required for their manufacturing, then we have green house gas intensity and green house gas intensity. It is green house gases are actually the group of substances that contribute to global warming; for example, carbon dioxide, methane, nitrogen oxide, and chlorofluorocarbons, hydro fluorocarbons and these are released from natural sources, but combustion of fossil fuels is involved, agriculture activities are involved, waste generation is involved and industrial processes over the past have increased their concentrations well, beyond the historical levels in the recent years. So, this is what is happening.

So, residual intensity is evaluated as weight of inputs. Here, I am talking about all inputs right, inputs plus weight of the fuel consumed minus weight of all the products. So, there are certain residuals, if you could recall, we took an example of car manufacturing in our life cycle analysis. In that example we had residuals for example, 100 kg of total material was the input and the material that went to the next processing. Next stage of processing was about, if I say 900 kilograms. This 100 kilo, kilograms was my residual. So, this residual intensity in certain cases is high. This is maybe the weight of releases to surface water to land to land fields to disposal. So, this is all this is residual to land to air to water residuals, go in all these things then certain treatment certain recycling is happening and some energy recoveries maybe sewage GHG residuals go into all these areas here.

Next what I have is air release intensity. So, this air release intensity, some of this is already covered in our residual intensity, but this is often important concern cause. This

directly has an environmental impact, the pollution that is generated is depend this is dependent on the air release intensity, for example, dust particles, there chips very small size, chips are there, aerosols are produced, all that is part of air release. So, that effects our internal environment in our factory and also the society the (Refer Time: 09:10) like people who are leaving around our factory. So, if it is all accumulated for example, in an industrial harbor or in an industrial park, if there are numerous industries or number of industries, which are producing air pollution, the society or the communities that is living by side of it or even the whole other even the, further communities maybe affected by this one. So, this is very important.

Similarly, water release intensity also deteriorate the health, then proportion of natural land proportion of natural land is not an absolute measure of sustainability of the facility. It actually does indicate the intensity of land, used for facility. So, by providing some natural cover, it is assigned to employees and to the surrounding community that environmental performance is a concern of the facility. Now, in my final product, there are these seven indicators in this again I have the recycled or reused content. So, in my product case in the, this stage the first indicator here is out of these 8 indicators. The first one recycled or reused content and we have recyclability as well here. So, are these two different, this is actually the content of the product, that can be recycled and some content may not be recycled that directly goes to land field. So, this is the something, that can be used for example, thermoplastics materials can be remolded. Metals can be remolded casting can be done again. This is recycled or this is the content the weight of the material that is there.

Recyclability is actually the ability of the material to get recycled. So, this actually every product is manufactured to be either recycled or reused or remanufactured or maybe biologically de degraded or to reduce the demand for non renewable resources and to keep the products out of waste stream. So, recyclable content is there. Now, these two are dependent on each other. Now, by at this renewable materials content, what we mean is that how much is the material, that can be renewed by renew, I means this is actually the indicator, that is very similar to the described in this portion, renewable material intensity. This is very similar, to this one what is our non renewable material intensity, here that is using renewable material intensity reduces the demand for non renewable resources, it works on this approach here.

So, this indicator measures the renewable materials content, which is derived for only plants and animals of all the products, that are produced in the facility in a specific reference. Similarly, in the same lines, we can have non renewable material intensity, restrictive substance content is, this is in the product earlier, we had in the inputs. So, these are again the (Refer Time: 12:29) substances that is there in the product, which are restricted by a law. There are legalities involved in this. The energy consumption intensity, which is operational energy, for example, we have starred equipment air conditions are there, if it is not starred, if it is a 2 star or maybe 5 star. In this case 5 2 star is more energy intensive, 5 star is less, if everything all is same here, all other variables are comparable, then only. Then green house gas emission intensity, this is again similar to this in operation. So, this is again connecting to this one.

So, next I will try to discuss the indicators with respect to the product and my factory level maybe not factory industrial overall.

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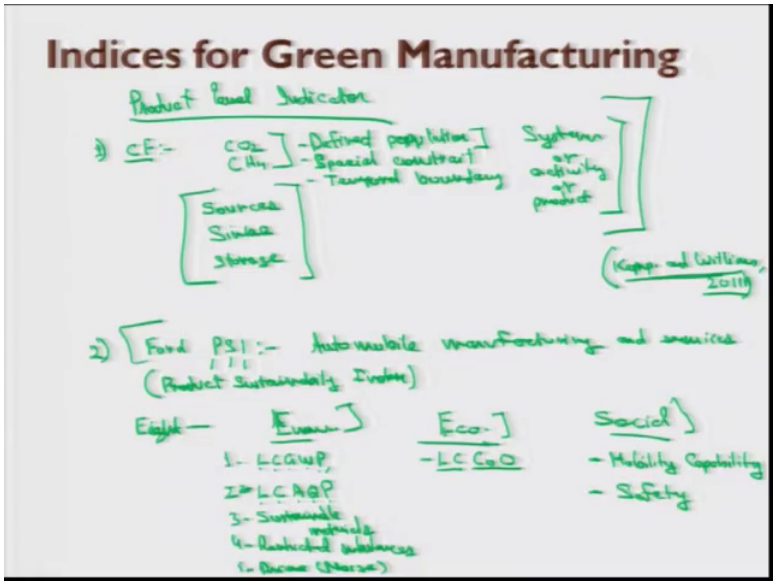

Certain indicators were developed, which are being used as well for instance; indicator, CF very well known thing. Carbon footprint is very prominent indicator one of the pertinent indicator that is being used and this what is this is actually the amount of CO 2 or maybe carbon dioxide or maybe methane gas, that is these emissions of these gas is for a defined population, for a specific system or activity or product. So, this consider all the relevant sources, this indicator is a actually given by Kemp and Williams in 2001.

This was given by Kemp and Williams in 2011. Now, this indicator involved all the relevant sources, syncs and the storage sources syncs and storage, the carbon footprint, at all these levels that this is actually within our special constraints, we find population and I would have special constraint and also my temporal constraint here. So, this was one of the indicator given by these researchers. So, this is one of the indicator that is at a product level and is given by these researchers in 2011.

Another indicator is that is specifically for automobile manufacturing was given by a ford that is ford PSI, this ford PSI, but PSI, we means product sustainability index

Now, what is this, this PSI, it considers this sustainable indicators, within the environmental economical societal emissions. All this, those three pillars, those are specifically related to automobile manufacturing. I will put the name here as well product sustainability index. So, it is manufacturing and even services. So, PSI predominantly looked at the 8 different variables across the 3 pillars, that is environmental economic and social you can even say societal as well here. So, in environment indicator, they have lifecycle global warming potential. This is lifecycle global warming potential, then they have lifecycle air quality potential, then they have sustainable materials, by sustainable material, we mean biodegradable materials that are being used, or being incorporated in automobile manufacturing here.

Then restricted substances and the last indicator here is, drive or maybe drive (Refer Time: 18:34) Here, right in economic area, they had only indicator, that is lifecycle cost of ownership, if you could recall my previous lecture, we discussed what is cost of ownership. So, this is lifecycle cost of ownership as one of the indicator here; that is involved by ford. Now, in social indicators, this had mobility capability of the automobile and very obvious safety has to be one of the indicator. So, we had 1 2 3 4 5 6 7 and 8 indicators in total and this was given by ford. So, the next indicator, I like to discuss, here is lifecycle sustainable assessment.

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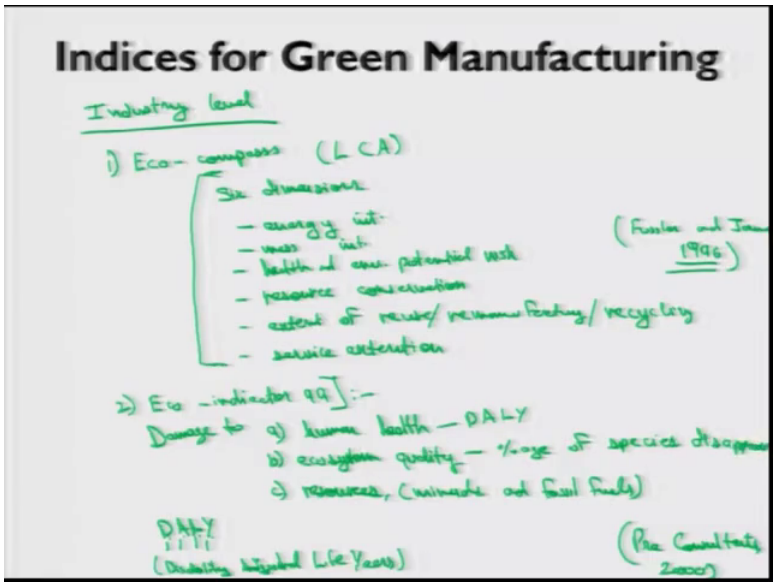

This term was given by Clifford in 2008, who used the same approach that is from cradle to grave to given indicator for green manufacturing.

Now, what he says, this lifecycle sustainable assessment. This one is equal to or this one is proportional to I would say lifecycle assessment and lifecycle costing and social lifecycle assessment. So, please do not fell into these terms, these lifecycle assessment we have discussed in detail do not get confused by these terms. So, the only difference is that, this person has just changed the names and this is more focused on costing. Only this is more focused on social or societal benefits. Here, F is more prominent here and this is our general lifecycle assessment. So, these days actually LCSA is when we say LC, only LC is sometimes also can be replaced as LCSA lifecycle sustainable assessment. So, next are the indicators, those are at industry level at the industry level, the indicator that is there is, one is eco compass, which was given by Fussler and James in 996. Now, what he says, this eco compass, actually, this was developed by (Refer Time: 22:01) chemical to provide a simple visual summary of LCA data, this all is dependent upon LCA data eco compass has 6 dimensions here which are energy intensity, then mass intensity health and environment potential risk then resource conservation extent of reuse or maybe with remanufacturing recycling in and then service extension.

So, you can see these are very similar to those given by OECD. OECD has even give more detailed and maybe kind of comprehensive indicators, but this was developed way before that, right next is eco indicator 99. So, this was given by pre consultants in 2000, actually in 99 only. So, it is a state of art of the damage oriented lifecycle impact is sustained that is, what is the damage that is there to the environment. It addresses three damage categories; damage to human health, damage to next is eco system quality and resource is maybe mineral and fossil fuels.

Now, damage to human health is actually a represented by this termm D A L Y, what is D A L Y, which is disability adjusted life years that is what is the life years that a normal human being can live with that damage, that is there due to our industrial waste or industrial impact, for this is disability adjusted life years and damage to eco system are expressed at percentage of species that have disappeared. This is actually DALY, this is percentage of species, this appeared due to the environmental impact and the resources. Those are there, that is the intensity of resources that are being used.

So, next I have an indicator that was developed by CII. This is confederation of Indian industries in 2011.

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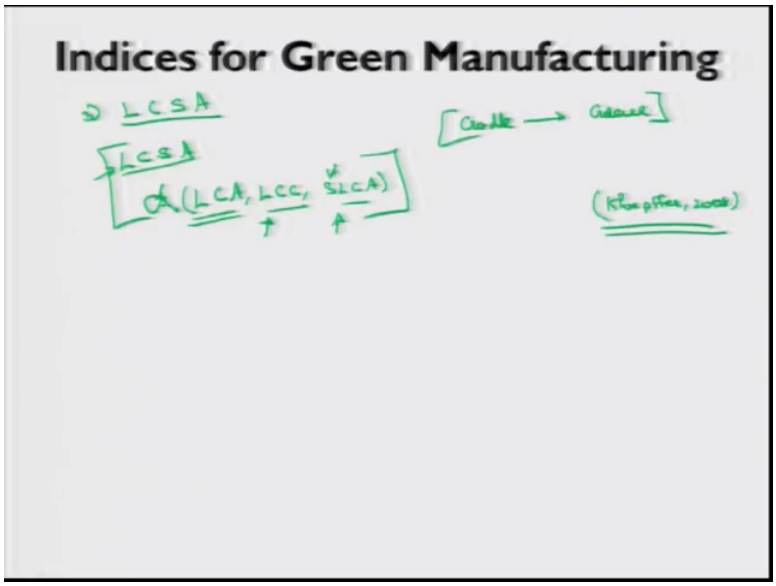

So, they developed green co rating system where in energy efficiency, water conservation, renewal energy, green house gas emission, waste management material, conservation, green supply, chain product (Refer Time: 26:50) lifecycle analysis and

some other areas like factory, ventilation, surroundings, site selection all those were there and they had this kind of rating criteria.

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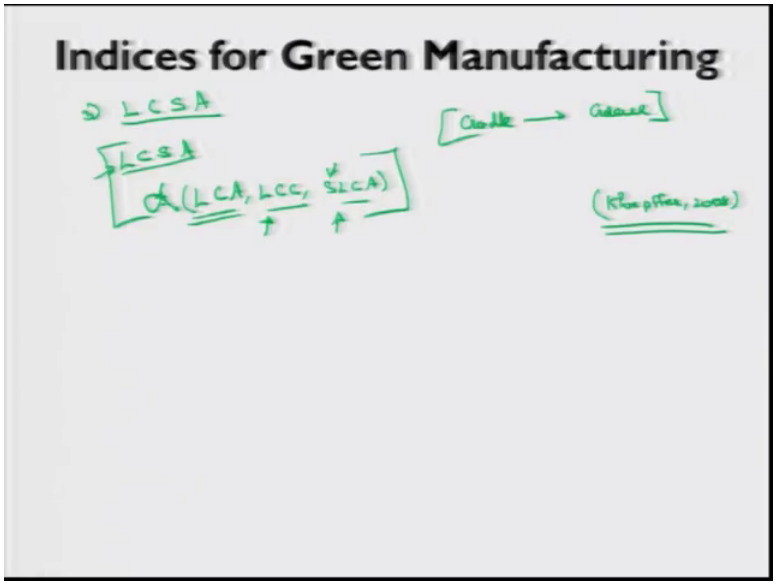

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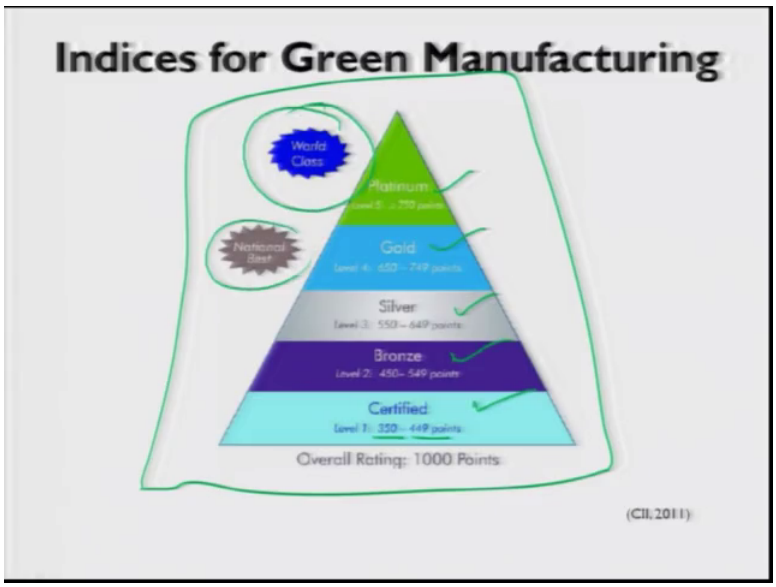

So, in this case they had platinum, gold, silver, bronze and the certified ratings, because these are all different levels. So, level one is, if they get these much number of points, they are actually all the indicators, which I have just mentioned here, like energy, water, intensity and other similar indicators, these all had some points associated with them and the points were given here and it was certified, that it is this companies for example, one

company is just satisfied, other company has more CO number of points, it is bronze and this is a kind of a world class company and this is national best company, if it is gold kind of national best. So, this is there in India.

So, what are the number of indicators that are required to benchmark my factory or to (Refer Time: 28:00) of my factory or level of my factory at the present state.

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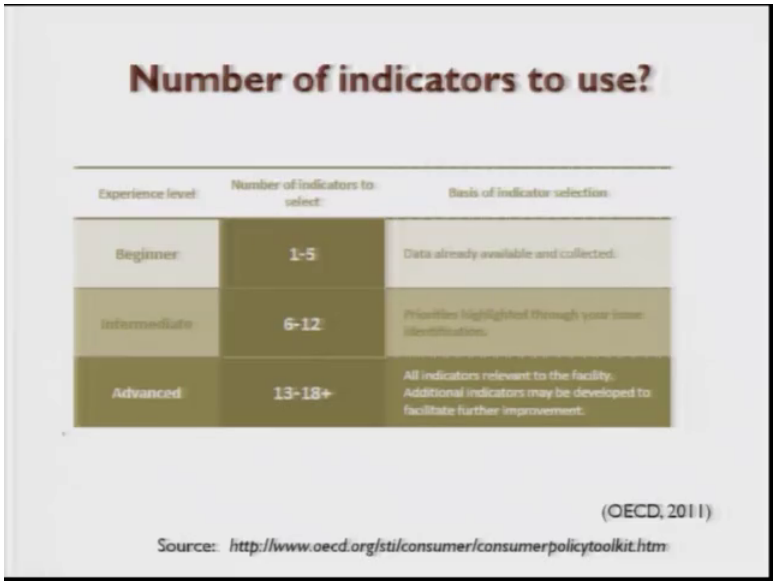

So, what is there this OECD says that at the beginning level, you have just started thinking about green manufacturing 1 to 5 indicators are enough to select that is the data is when the data this is for indicator here, say selection is the data is already available and collected. So, just start with one or maybe a single indicator we can just start even with one single one only.

So, start with this one and explore your intensions towards eco efficiency toward societal benefits start with something maybe 1 to 5. So, when one has started at intermediate level, more number of indicators maybe included, they say it is, it can be 6 to 12 with intermediate level when one is working towards sustainable development or working towards green manufacturing then the qualities must be highlighted through issue identification. So, what is the specific issue they need to work on?

Now, they know the state of this their factory, here at this point, now at second level they need to add more indicators. Now, at advanced level they said 13 to 18 plus indicators

are there. So, these 18 indicators are all the OECD indicators plus some specific indicators, related to the factory which we are concerned with, can be included. So, all indicators that relevant to facility, additional indicators may also be developed to facilitate further improvement, this is the advanced level. So, it all depends what color or factory is in the present state and our purpose is just to go to the next step. So, this was all about the indicators that are there to know the state or level of my present state of my factory or maybe product.

So, if we talk in India the things are moving there are certain companies, who are at all the different levels, here the companies who are beginners. This small scaled companies or medium scaled companies, they had started this thing, there are good large scaled companies, who are at intermediate and advanced level as well for instance I would say LG has come up with a LED, that is the model is LED E 60 and this has 40 percent less energy consumption and similarly, Samsung has also produced a LED in same lines.

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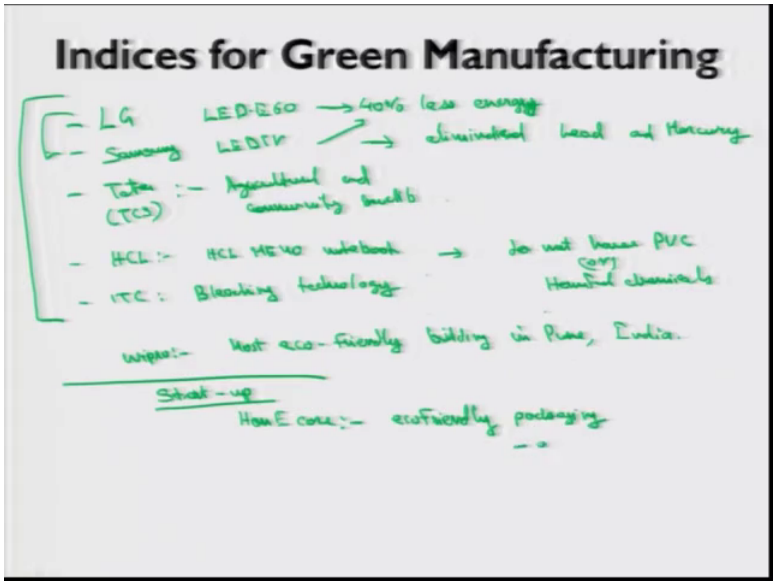

It has also produced LED TV, which also has 40 percent less energy and also they have shown their commitment towards green manufacturing by eliminating lead and mercury from this. So, also Tata, it is actually TCS, it is contributing to agriculture and community benefits, and in the similar fashion with LG and Samsung, HCL has also come up with a notebook, that is HCL ME, 40 notebook, in which they do not have any PVC or harmful chemicals.

So, the status in India is also good also like ITC. ITC is has introduced a bleaching technology, that is ozone treated and elemental chlorine free bleaching and the in service sector as well, the things are going well for example, when we ask for a transaction slip in ATMS, they always give message, please do not print or (Refer Time: 32:40) printing in Indian railways, always the message is there, please avoid to print the ticket use mobile services or online services for that. So, those are sustainable efforts towards sustainable development. So, the backing sector is discouraging the use of paper and also WIPRO is contributing. It has a technology to prevent ways and it has most eco friendly building in Pune also. We have startups, those are working toward green or sustainability like for example, I have put one or two names (Refer Time: 33:40) is there who does eco friendly packing.

It also they say that they try to eliminate wood from their backing and there are other startups like nurturing green, they promote giving green gifts and these gifts maybe plants or organic foods also. These are organizations who are working in agriculture sectors and there are certain startups, certain NGO'S are there and they are working towards increase in yield of organic products, that is actually their products is vegetables and fruits and besides these indicators eco compass, eco indicator and green rating system, there are also global indicators like GEN, that is global eco labeling network. So, they actually give certification for giving manufacturing. So, ISEAL is there, then we have European green capital.

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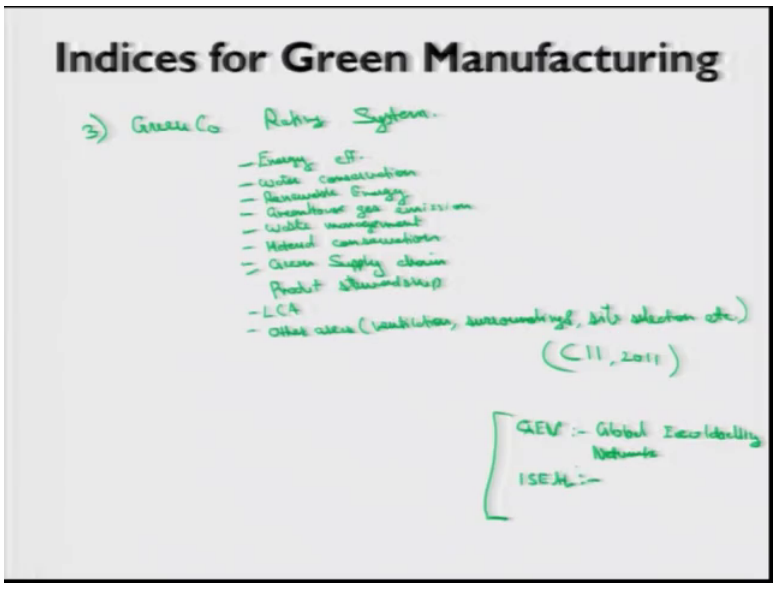

So, with this I will conclude this lecture and we will come up with green manufacturing system model in next lecture, and in this lecture I have discussed various indicators at product level and industry level, those are there to state to give us the level or state of our manufacturing concern or product.

Thank you.